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A Cultural Framework for the Interoperability of C2 systems

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Abstract

In considering some of the difficulties experienced in coalition operations, it becomes apparent that attention is needed, is in establishing a cultural framework for the interoperability of personnel (the human agents) and the IT/IS infrastructure that they share. This paper extends the argument proposed in previous work (Burke 2000a; Burke 2000b; Slay 2001, Slay & Burke 2001)] that culture is an important system variable within any complex socio-technical system, such as a C2 system.

The IFIP-IFAC (1999) Task Force has developed the Generalised Enterprise Reference Framework and Architecture (GERAM). GERAM allows the merger of change process methods from different disciplines and examines both the “products” of a system and the “business” processes by which they are produced. However, while recognising the role of human agents within the system, the GERAM framework does not cater for any cultural differences within the processes of decision making, monitoring, commanding and controlling or bringing about change.

This paper extends the GERAM framework with theoretical anthropological and organisational frameworks discussed in previous work (Slay 2001, Slay & Burke 2001) and creates a specific cultural framework that is applied to the interoperability of C2 systems in coalition operations.

1. Culture, Complex Socio-Technological Systems And The War On Terrorism

Even before the horror of the terrorist attacks of September 11th 2001, cultural issues had already become an important issue for researchers and users of distributed computing systems. The growing number of attacks on supposedly secure computer systems, such as that of the White House and Pentagon, were already causing considerable concern to Western governments.

These kinds of attacks first predominated within e-commerce, and have become even more of a problem as government and the military begin to offer many more of their services online, or rely more heavily on distributed information systems to provide their operating data. Organisational aspects of Information and Communication Technology (ICT) security become important, making it clear that technology alone cannot lead to an adequate solution. A proper analysis of security requirements reveals that the issue of system security has to be dealt with at different levels. One hypothesis is that these

levels follow the phases of the software design process; others group security requirements according to the ISO-OSI or IEEE network architecture models. Both approaches do however only cover the ICT architecture and infrastructure of a company. They do not deal with the related organisational issues that are directly linked to the technological ones. Some of the major organisational issues to face are the human social and cultural factors within IT security. Although media focuses on external attacks to systems, it is recognised that up to 40 % of IT security related crime arises from malice or error from staff of the organisation (Davey 2001).

Since September 11th 2001, the paradigms of Western governments, their defence forces and defence researchers have been challenged as they have been forced to consider the effect of culture – in this case a fundamentalist belief system – within their complex organisations and ICT infrastructures, and to take seriously attack scenarios, both physical and cyber terrorist in nature, which originally would have been discounted as far fetched or science fiction. It was stated (CCRP 2001) that in the attack on the World Trade Centre “disaster and crisis environments created difficult conditions for human decision makers and the socio-technical systems they interact with ... the design of effective response systems requires a socio-technical approach”. They believe that the solution to what they identify as their own complete organisational failure is a “new pattern of interaction ...a response system (which)...can be seen to evolve through self organizing behavior of component units into a complex adaptive system”.

The context of this paper is that current systems engineering (SE), software engineering (SWE), computer science (CS) and information systems (IS) research recognises (Cook & Sproles 2000, Mitleton-Kelly 2002) military command and control (C2) systems as complex socio-technical systems, since they can be idealised as open systems that “depend on the technology, the sentiments of the members, and the organisational environment” (Checkland 1981). Although these systems are organised to focus on a primary task, this task and the outcomes (from the system) cannot be separated from the environment and the social factors within which the system is operating.

Much recent research from CS, SWE, SE and IS identifies *culture* (also expressed synonymously as *sense making*, *viewpoints* and *world view*) as an important variable within those systems. Some of the issues and research questions which arise within command and control scenarios include:

- Does national culture affect the way an individual uses the computer and the interfaces he or she might choose? Which interface elements are more problematic? (Cagiltay 1999)
- Is there a cultural effect on the cohesiveness of distributed teams working in a technologically mediated manner across national boundaries? (Rathod & Miranda 1999; Vogel *et al* 2001)
- How can we develop and manage cultural differences in virtual teams? (Dafoulas & Macaulay)
- How can we develop a guide for the American military to incorporate cross-cultural perspectives within ICT development? Would the use of the concepts of complex socio technical systems and self-organisation aid in this process (CCRP 2001)

While the effects of Sept 11th focus our attention on the role of culture within the context of cyber-terrorism, and consider its role within offensive or defensive action on military information systems, this paper examines the positive side of this issue by asking questions such as:

- How can we develop an understanding of the effect of culture on co-operation, coalition operations and interoperability of personnel (the human agents) and the IT/IS infrastructure that they share?
- How can we model this within a command and control context?

In answering these kinds of questions it becomes apparent that firstly one has to develop a theoretical foundation for understanding culture and recognising its effects within a complex socio-technological system such as a military peacekeeping force working within a coalition operation. Secondly one has to be able to model this military force and particularly its command and control systems (here this means its personnel, its knowledge systems, its information systems and its ICT infrastructure).

2. Theoretical Cultural Foundations for Complex Socio-Technological Systems Research

It is recognised (Straub *et al* 2002) that cross-cultural work in this area “remains in its infancy” because of the “lack of unanimity about the underlying meaning and definition of the underlying construct “culture””. Culture is most commonly defined as a set of shared values, shared understanding or even shared methods of problem solving but some (e.g. Hall 1976) still use a definition of culture that is all-encompassing (Straub *et al* 2002) and abstract in manner and which provides very little help in the identification of cultural properties. These various definitions and understandings of culture have led to a wide range of approaches from those who are dealing with cross-cultural issues in HCI, IS, CS and military command and control (C2) systems. These approaches generally involve identification of a series of values which are shared by every culture (e.g. age-grading, taboos, numerals, tool making (Murdock 1965)) and then studying individuals within specific communities to understand for example that particular community’s taboos, and how this might effect the community’s decision making or learning processes.

Significant contributions to an understanding of the effect of culture in IS, and more generally in ICT, have been made by Hofstede (1980, 1983, 1991, 1998) whose work in assigning a culture-value by assigning cultural dimensions to a particular group of people is widely referenced (e.g. Dafoulas & Macaulay 2001; Vogel *et al* 2001; Straub *et al* 2002; Rathod & Miranda 1999; Cagiltay 1999). Hofstede’s work is highly regarded but an examination of his work a major problem with Hofstede’s analysis is that it is relatively simplistic in a more modern cross-cultural environment since he identifies only four factors (dimensions) by which one culture is differentiated from another. These are *power distance*, *collectivism v individualism*, *femininity v masculinity* and *uncertainty avoidance*. This is as opposed to Murdock (1965) who found seventy-two different factors. Hofstede’s methodology involved interviewing large numbers of employees of IBM internationally and questioning them about issues such as their opinion of their supervisor’s decision making style. From this data, he

produced cultural indicators (quantifiers) for many nationalities. Another weakness of his methodology is that these values are assigned to a culture and so no allowance can be made for example for multiculturalism (i.e. this does not allow for the cultural differences which are displayed and valued by ethnic minorities internationally or for individuals such as Chinese or Greek Australians who may display characteristics of two cultures in their behaviour and decision making)

Others have derived different value-sets in a similar manner and applied these within organisational and professional cultures (Laurent 1991; Schein 1997) but a literature review has not produced a theoretical model that will allow for the identification and measurement of culture in the engineering of complex information systems. It is unclear to modern researchers in these fields whether culture is the structural phenomenon that Hofstede proposed, or even whether it has unique generalisable characteristics. It is thus very difficult to investigate, identify, model or measure cultural effects while there is still widespread epistemological debate as to the primary nature of culture.

Straub *et al* (2002) comment that it is the lack of clear concepts which makes cross-cultural research in the engineering of complex information systems difficult to conduct, and also links the effect of this lack of clarity to our inability to “develop and refine theories” and to explain why there is difficulty in explaining the high degree of variance in current predictive models.

While there is no apparent agreement within SE, SWE, CS and IS research, several candidate theories exist for the conceptualisation and measurement of culture in the engineering of complex systems. Straub proposes that Social Identity Theory (SIT) (Tajfel 1978) is a candidate theory for a positivist (scientific) model of the role of culture. This theory presupposes that individuals know whether they belong to a cultural group or not queries individuals as to the extent to which their cultural values resemble those of others in a particular cultural group. Straub notes that SIT would allow the robust positivist method of “comparison and contrast” and allows variation in measures of social identification within a particular group. (Here one may define positivist methods as those whose research validity may be measured scientifically (Guba & Lincoln, 1985) by generalisation, reliability and objectivity).

Another candidate theory may be borrowed from science education. Cobern’s (1991, 1995, 1998; Cobern & Loving 1998) research appears to stand alone within science education and gives a clear understanding of the role of culture in learning scientific principles and even in developing the ability to apply “scientific” reasoning and thus providing a positivist model of the role of culture. Cobern’s strength is that he introduces the Kearney (1984) anthropological model of world view so as to provide an anthropological framework around which to structure an understanding of the role of culture in science education. His methodology however is similar to Straub’s inasmuch as he queries his subjects as to their own understanding of their conceptualisations and thus derives his assertions through a process of deductive scientific reasoning. Other candidate theories include Hong *et al*’s Dynamic Constructivist Analysis (DCA) (2000) and Straub *et al* (2001) Cultural Influence Modelling (CIM).

3. Applications in Complex Systems and Culture

Soft systems methodologies (Checkland 1981), Kline's complexity hypotheses (Kline 1995) and theories of complexity drawn from disciplines such as computer simulation, mathematics and physics (Mitleton-Kelly 2002, p1) have provided helpful insight into the conceptualisation, analysis, engineering and development of complex information systems. This involves producing three perspectives (views) of the system being developed (Kline 1995). These views are:

- *A synoptic view*: an overview with a top-down approach for extracting and synthesising system properties
- *A piecewise view*: one that identifies and examines the smallest portions of a system that might be relevant in providing information to aid in the solution of any particular problem within the system.
- *A structural view*: one that provides details of how each piece fits together within a particular system as well as providing information on the relationship between local and global effects within the system.

In previous work these have provided an overarching theoretical framework at the macro level for an exploration of this issue (Slay 2001; Slay 2002; Slay & Burke 2001, Quirchmayr & Slay 2001).

Once cultural effects are able to be measured scientifically, emergent cultural properties within complex systems may then be recognised. Other complexity principles, such as feedback, may also be considered and applied so as to provide increased predictability and control (Mitleton-Kelly 2002) within the system under examination. In her approach to complex evolving and highly technological systems, Mitleton-Kelly worked with several complex British engineering enterprises such as Rolls Royce, to enable them to manage the "co-evolution between changing business processes and information systems development". She reports successful tests of aiding organisations, knowingly applying complexity theory within problematic situations, to co-evolve within a changing environment.

4. Modelling The Military Command And Control Enterprise

In previous work (Slay, 2001) I drew on Cobern's (1991) application of Worldview Theory to provide an understanding of culture (although, as described, this is one of several candidate theories) and Kline's analysis (1995) to depict the role of culture within a system. One of the extensions needed to improve this work is a better method of modelling the military enterprises involved in a coalition operation.

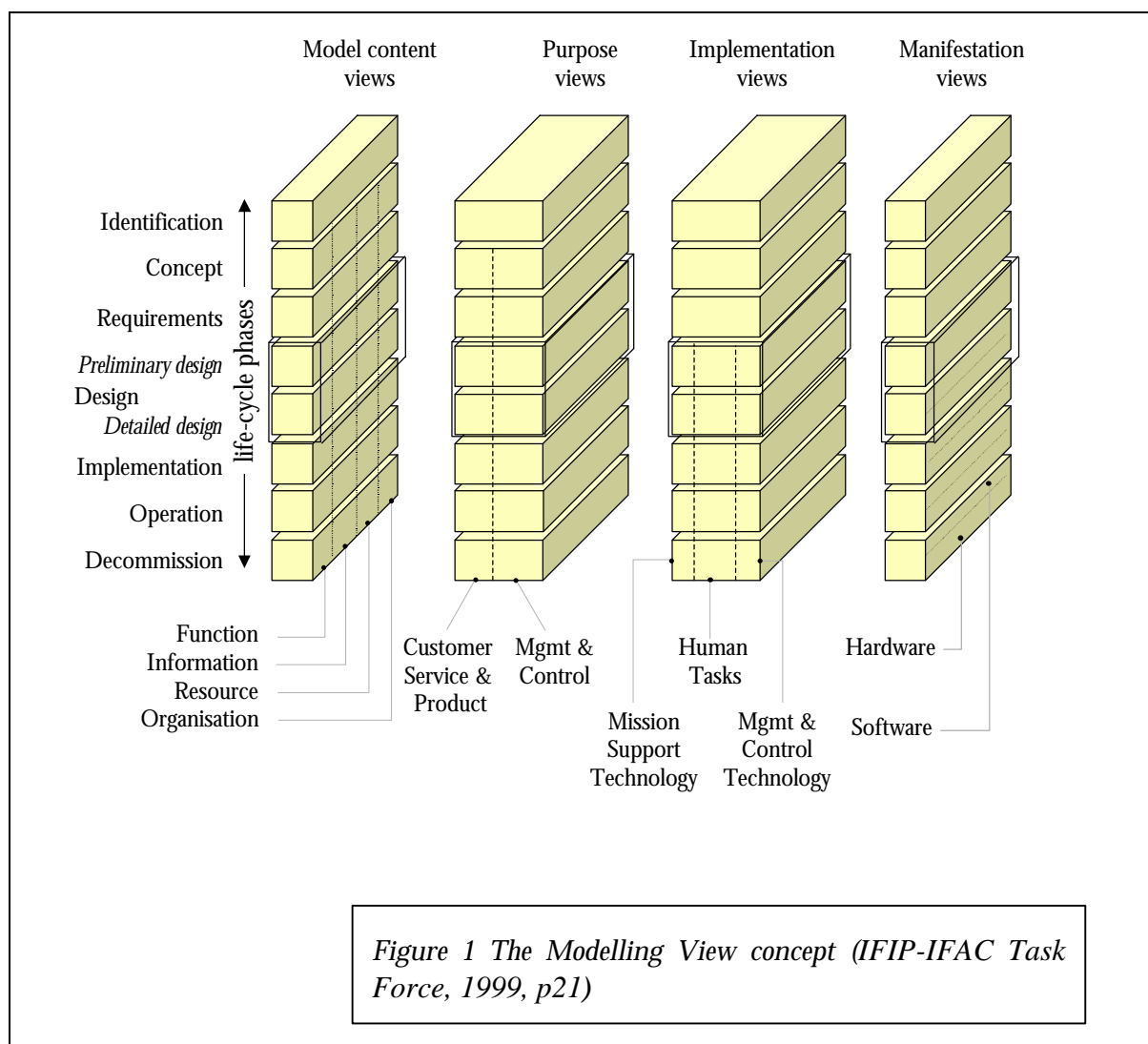
The IFIP-IFAC [1999] Task Force has developed the Generalised Enterprise Reference Framework and Architecture (GERAM). This "defines a tool-kit of concepts for designing and maintaining enterprises for their life history". As such it is not itself an enterprise reference architecture but a method of organising previously existent architectures and integrating current knowledge.

GERAM allows the merger of change process methods from different disciplines and examines both the "products" of a system and the "business" processes by which they are produced. However, while recognising the role of human agents within the system in decision support and operation monitoring and control, and also as a change agent,

the GERAM framework does not cater for any cultural differences within the processes of decision making, monitoring, commanding and controlling or bringing about change.

GERAM is defined as “ the generic concepts recommended for use in enterprise engineering and integration projects. These concepts can be classified as human oriented concepts and process oriented concepts. Human oriented concepts “cover human aspects such as capabilities, skills, know-how and competencies as well as roles of humans in the enterprise organisation and operation. The organisation related aspects have to do with decision level, responsibilities and authorities, the operational ones relate to the capabilities and qualities of humans as enterprise resource elements. In addition, the communication aspects of humans have to be recognised to cover interoperation with other humans and with technology elements when realising enterprise operations.” (IFIP-IFAC Task Force, 1999, p7)

The GERAM model has an emphasis on the fundamental role of humans within the enterprise and notes that although it is not practical to model all aspects of human roles within an enterprise, “concepts are required to formally represent those human factors connected with enterprise integration. This should be achieved in a way which harmonises human roles with that of other human and technology elements, as an integral part of the organisation and operation of an enterprise. Hence the need for



constructs which promote the capture of knowledge (possessed by humans) in the form of reusable enterprise models about:

- the role of individuals and groups of individuals,
- the way in which organisational structures and constraints are applied to co-ordinate those roles, such as via the delegation of responsibilities and control and reporting procedures, and
- the capabilities and qualities of humans, treated as resource elements.”

The GERAM model allows for process-models and considers generic life cycle phases which are easily applicable to military command and control operations. The most powerful aspect of the GERAM model for C2 scenarios is the Entity Implementation View which allows the presentation of “different views based on the division between human- and automated tasks. These include a

- *Human Activities View* -information related to the tasks to be done by humans and contrasts tasks which may be done by humans (“extent of humanisability”) and those which will be done by humans (“extent of automation”).
- *Automated Activities View*- all the tasks to be done by machines, including tasks to be carried out by mission support technology and those carried out by management & control technology (i.e. "technology tasks").
- *Entity Physical Manifestation Views*
 - *Software View*
 - *Hardware View*

When two coalition forces are modelled using the GERAM framework then it is easy to identify the human activity within each system at various part of the operation life cycle.

As was described previously it is then possible to use World View theory and its universal “cognitive categories” to analyse members of two culturally different forces once an enterprise view such as that shown in Figure 1 above has been produced. Worldview theory gives an opportunity to examine the system from the individual human operator upwards and to determine his or her particular response to:

- The Other
- Classification
- Causality
- Relationship
- Self
- Time & Space

With this understanding it is therefore possible to predict the response of an individual to a particular stimulus or change and to begin to have an understanding of the effect of this change on the system dynamics. These have been described in previous work but, taking Relationship, as an example , it is possible thus to use an analysis which

“classifies” individuals from different cultures and develop a series of attributes to represent the cultural factors under consideration.

Examples of Relationship that have impact on military communications and information systems include command approach, problem solving strategies, method of motivating subordinates etc.

5. Conclusion

The GERAM framework allows the modelling and visualisation of enterprise and can be applied to a military enterprise. Its greatest power is in its modelling views which allow the identification of human and automated activities and allow us to differentiate between software and hardware tasks.

When applied in conjunction with theoretical concepts of culture, from anthropology or the social sciences, these views can be used to describe the effect of culture within an enterprise and thus to identify areas of potential conflict and weakness caused by culture.

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